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Effect of Corn Processing on Degradable Intake Protein Requirement of Finishing Cattle

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Degradable intake protein requirement of finishing cattle is affected by method of corn processing and presumably rate and extent of ruminal starch fermentation.

Summary

Three finishing trials were conducted to determine effect of corn processing on degradable intake protein requirement of feedlot cattle. Finishing diets consisted of 82% processed corn which was either dry rolled, high moisture, or steam flaked. Degradable intake protein levels were achieved by adding 0 to 2.0% urea (DM basis) to the control diets. Estimates of degradable intake protein requirement for a dry-rolled corn-based diet were approximately 6.3% of dietary DM. Degradable intake protein requirement for high-moisture corn-based diets was approximately 10% of dietary DM. Degradable intake protein requirement for steam-flaked corn-based diet was between 7 and 9.5% of dietary DM.

Introduction

Degradable intake protein (DIP) is the fraction of feed crude protein which is available to the microbial population. In typical diets for finishing cattle, DIP is composed of both degradable true protein and non-protein nitrogen. A deficiency in DIP would have two effects. First, DIP deficiency would lower microbial crude protein production, possibly resulting in metabolizable protein (MP) deficiency if sufficient UIP was not supplemented. Second, DIP deficiency would reduce energy yield from carbohydrate fermentation, thereby lowering volatile fatty acid production and energetic efficiency of the diet. Therefore, a deficiency in DIP may lead to reduced finishing performance even when the animal's metabolizable protein requirement has been met.

Level 1 of the 1996 NRC model predicts that DIP requirement for a typical dry-rolled corn-based finishing diet is approximately 6.8% of dietary DM. Few data exist that directly evaluate the effect of corn processing on DIP requirement. Average ruminal starch digestibilities of 78, 89 and 83% for dry-rolled, high-moisture and steam-flaked corn have been reported. It is our hypothesis that grain processing methods which increase rate and extent of starch fermentation may increase the dietary DIP requirement relative to dry-rolled corn. Objectives of these experiments were to determine DIP requirements of finishing cattle fed dry-rolled, high-moisture and steam-flaked corn-based finishing diets.

Procedure

Trial 1

Two hundred and fifty-two crossbred yearling steers (834 lb) were used in a randomized complete block design to determine DIP requirement of finishing steers fed a high-moisture corn-based diet. Steers were split into three initial weight blocks and randomly assigned to one of 12 pens and to one of four dietary treatments (21 steers per pen, 3 pens per treatment). Dietary treatments consisted of four levels of dietary DIP that were accomplished by adding 0, .4, .8, or 1.2% urea to the base diet (DM basis).

High-moisture corn-based finishing diet (HMC) is shown in Table 1, while dietary crude protein and DIP values are shown in Table 2. High-moisture corn was harvested at approximately 29% moisture, processed through a rollermill, and stored in a covered concrete bunker. Steers were adapted to finishing diet in 21 days using alfalfa hay to replace high-moisture corn (50% alfalfa for 3 days, 40% of 4 days, 30% for 7 days, and 20% for 7 days, DM basis). Cottonseed hulls were only included in the finishing diet.

Steers were weighed initially on two consecutive days after being limit-fed at 2% of body weight for 5 days in order to minimize differences in gut fill. Steers were implanted with Synovex Plus on day 1 and fed for 108 days. Final weights were calculated using hot carcass weights adjusted to a common dress (63%). Data were analyzed using linear, quadratic and cubic contrasts. Nonlinear analysis of feed/gain was used to predict the DIP requirement.

Trial 2

Two hundred and sixty-four crossbred yearling steers (781 lb) were used in a completely randomized design to determine DIP requirement of finishing steers fed a steam-flaked corn-based diet. Steers were stratified by initial weight to one of 24 pens (11 steers per pen). Pens were randomly assigned to one of six dietary treatments (4 pens per treatment). Treatments consisted of six levels of dietary DIP which were accomplished by adding 0, .4, .8, 1.2, 1.6, or 2.0% urea to the base diet (DM basis). Steam-flaked corn-based finishing diet (SFC) is shown in Table 1, while dietary crude protein and DIP values are shown in Table 3. Steam-flaked corn was processed to a flake density of 29 lb/bushel at a commercial feedlot facility and hauled to the research feedlot on a weekly basis. Steers were adapted to finishing diet in 21 days using alfalfa hay to replace steam-flaked corn (40% alfalfa for three days, 30% of four days, 20% for seven days and 10% for seven days, DM basis). Cottonseed hulls were included at 5% of DM in all diets.

Steers were weighed initially on two consecutive days after being limit-fed at 2% of body weight for five days to minimize differences in gut fill. Steers were implanted with Synovex C on day 1, reimplanted with Revalor S on day 47 and fed for a total of 129 days. Final weights were calculated using hot carcass weights adjusted to a common dress (63%). Data were analyzed using linear, quadratic and cubic contrasts. Nonlinear analysis of feed/gain was used to predict the DIP requirement.

Trial 3

Ninety crossbred yearling steers (612 lb) were used in a completely randomized design with a 3 x 5 factorial treatment structure to evaluate effect of corn processing on DIP requirement of finishing cattle. Steers were randomly assigned to one of three finishing diets which were based on DRC, HMC, or SFC (Table 1). Within each diet, steers were randomly assigned to five levels of dietary DIP which were accomplished by adding 0, .5, 1.0, 1.5, or 2.0% urea to the base diet (DM basis). Dietary CP and DIP values are shown in Table 4. High-moisture corn and steam-flaked corn were similar to Trials 1 and 2, respectively, while dry-rolled corn was processed so that particle size was as coarse as possible with relatively few whole kernels passing through the rolls. Ideally, kernels were broken into approximately four pieces.

Steers were individually fed using Calan electronic gates. Steers were adapted to their respective finishing diet over an approximately 21-day period. Steers were offered their respective finishing diet on day 1 at 1.8% of body weight (DM basis). Feed offered then was increased .5 lb per day (DM basis) until steers were ad libitum. Steers were weighed initially on three consecutive days after being limit-fed at 2.0% of body weight for five days in order to minimize differences in gut fill. Steers were implanted with Synovex C on day 1, reimplanted with Synovex Plus on day 67, and fed for a total of 167 days. Final weights were calculated using hot carcass weights adjusted to a common dress (63%). Data were analyzed using Least Significance Difference method and linear, quadratic and cubic contrasts. Nonlinear analyses of feed/gain were used to predict DIP requirements.

(Continued on next page)

Table 1. Composition of finishing diets (% of DM).

	Diet[a]		
Ingredient	DRC	HMC	SFC
Dry-rolled corn	82.0	—	—
High-moisture corn	—	82.0	—
Steam-flaked corn	—	—	82.0
Alfalfa hay	5.0	5.0	5.0
Cottonseed hulls	5.0	5.0	5.0
Molasses	3.0	3.0	3.0
Dry supplement[b]	5.0	5.0	5.0

[a]DRC = dry-rolled corn, HMC = high-moisture corn, SFC = steam-flaked corn.
[b]All diets supplemented to contain a minimum of .7% Ca, .28% P, .6% K, and .15% S (DM basis). All diets contained 27 g/ton Rumensin and 10 g/ton Tylan (DM basis).

Table 2. Dietary protein composition and finishing performance for high moisture corn-based diet (Trial 1).

	Treatment				
Urea, % of DM	0	.4	.8	1.2	SEM
Crude protein, % of DM[a]	10.7	11.9	13.0	14.2	—
DIP, % of DM[a]	7.1	8.2	9.4	10.6	—
DIP balance, g/day	-19	122	262	403	—
MP balance, g/day	78	90	90	90	—
DM intake, lb	27.0	26.7	26.6	26.7	.2
Daily gain, lb[b]	3.75	3.77	4.01	4.08	.07
Feed/gain[b]	7.19	7.09	6.62	6.54	.19
Fat depth, in[c]	.35	.39	.39	.42	.02
Marbling score[bd]	523	507	502	493	8

[a]Based on NRC tabular values.
[b]Linear ($P < .03$).
[c]Linear ($P = .06$).
[d]400 = Traces 0, 500 = Small 0, 600 = Modest 0.

Results

Trial 1

Effects of DIP level on performance of finishing steers fed a high-moisture corn-based diet are shown in Table 2. Dry matter intake was not affected ($P = .75$) by dietary DIP and averaged 26.8 lb/day. However, both average daily gain and feed/gain improved linearly ($P < .03$) as dietary DIP increased. Nonlinear analysis of feed/gain predicted that the DIP requirement would be met by 1.1% urea (95% confidence interval was from 1.0 to 2.2%), which would provide a dietary DIP level of 10.2%. We hypothesized that DIP requirement for a high-moisture corn-based diet would be greater than 7.1% of dietary DM as predicted by 1996 NRC. However, we did not expect the requirement to be as high as 10.2% of dietary DM. This level of DIP is greater than is commonly fed in high moisture corn-based diets.

Trial 2

Effect of DIP level on performance of finishing steers fed a steam-flaked corn-based diet are shown in Table 3. Dry matter intake responded quadratically ($P = .01$) as dietary DIP increased. In addition, average daily gain and feed/gain also responded quadratically ($P < .0001$) as dietary DIP increased. Nonlinear analysis of feed/gain predicted a breakpoint at .8% urea (95% confidence interval was .79 to .88%). This dietary urea concentration would provide a dietary DIP value of approximately 7.1%. Level 1 of 1996 NRC model predicted that the DIP requirement would be met at 7.1% of DM.

Trial 3

Effects of DIP level on performance of finishing steers fed dry-rolled, high-moisture, and steam-flaked corn-based diets are shown in Table 4. Processing method x urea level interactions were found ($P < .01$) for DM intake and daily gain. Simple effects for feed/gain are also shown in Table 4, although no interaction was noted ($P = .34$). For DRC, dry matter intake ($P = .08$) and average daily gain ($P = .03$) responded linearly with DIP level. However, feed/gain was not affected ($P > .50$) by DIP level. Nonlinear analysis of feed/gain did not predict a breakpoint suggesting that the DIP requirement was met by the first increment of urea.

In the HMC diet, dry matter intake was not affected ($P > .10$), while average daily gain responded cubically ($P = .03$) with DIP level. Feed/gain was not affected ($P > .10$). Nonlinear analysis of feed/gain predicted a breakpoint at 1.1% urea. This level of urea suggests that dietary DIP requirement for HMC is approximately 10% of dietary DM, which agrees well with results from Trial 1.

In the SFC diet, dry matter intake and average daily gain responded quadratically ($P < .001$) with DIP level. Feed/gain responded linearly ($P = .007$) with DIP level. Nonlinear analysis of feed/

Table 3. Dietary protein composition and finishing performance for steam flaked corn-based diet (Trial 2).

	Treatment						
Urea, % of DM	0	.4	.8	1.2	1.6	2.0	SEM
Crude protein, % of DM[a]	9.5	10.6	11.8	13.0	14.1	15.3	—
DIP, % of DM[a]	4.7	5.8	7.0	8.2	9.3	10.5	—
DIP balance, g/day	-264	-135	-6	123	251	380	—
MP balance, g/day	-107	-24	58	62	62	62	—
DM intake, lb[b]	22.6	23.8	24.3	24.3	24.8	24.1	.4
Daily gain, lb[c]	3.17	3.82	4.40	4.40	4.44	4.48	.10
Feed/gain[c]	7.11	6.22	5.53	5.53	5.57	5.37	.19
Fat depth, in[d]	.37	.47	.51	.49	.51	.50	.02
Marbling score[de]	479	520	532	504	519	511	13

[a]Based on NRC tabular values.
[b]Quadratic ($P = .01$).
[c]Quadratic ($P < .001$).
[d]Quadratic ($P < .10$).
[e]400 = Traces 0, 500 = Small 0, 600 = Modest 0.

Table 4. Dietary protein composition and finishing performance for Trial 3[a].

	Treatment					
Urea, % of DM	0	.5	1.0	1.5	2.0	SEM
Crude protein, % of DM[b]	9.5	10.9	12.4	13.8	15.3	—
DIP, % of DM[b]						
DRC	4.8	6.3	7.7	9.2	10.6	—
HMC	6.7	8.1	9.6	11.0	12.5	—
SFC	4.7	6.1	7.6	9.0	10.5	—
DM intake, lb/day						
DRC	21.8[c]	21.1	21.9	23.4	22.8[c]	.8
HMC	23.0[c]	21.1	21.4	21.8	20.8[d]	.8
SFC[f]	17.8[d]	22.3	20.8	21.9	18.7[e]	.8
Daily gain, lb/day						
DRC[g]	3.39[c]	3.61[cd]	3.38[c]	3.96	3.70[c]	.14
HMC[h]	3.70[c]	3.45[c]	3.51[cd]	3.75	3.32[d]	.14
SFC[f]	2.99[d]	3.79[d]	3.72[d]	4.07	3.45[cd]	.14
Feed/gain						
DRC	6.41	5.81	6.49[c]	5.88[c]	6.17[c]	.22
HMC	6.21	6.13	6.06[cd]	5.81[cd]	6.25[c]	.22
SFC[g]	5.95	5.85	5.59[d]	5.38[d]	5.38[d]	.22
Fat depth, in	.42	.45	.45	.53	.43	.03
Marbling score[i]	511	530	519	535	501	13

[a]DRC = dry-rolled corn, HMC = high-moisture corn, SFC = steam-flaked corn.
[b]Based on NRC tabular values.
[cde]Means with unlike superscript within column differ ($P < .10$).
[f]Quadratic effect of urea level ($P < .05$).
[g]Linear effect of urea level ($P < .05$).
[h]Cubic effect of urea level ($P < .05$).
[i]500 = Small 0, 600 = Modest 0.

gain predicted a breakpoint at 1.6% urea (95% confidence interval was 1.55 to 1.66%). This level of urea suggests that dietary DIP requirement for SFC-based diet is approximately 9.5% of dietary DM.

Degradable intake protein requirement for DRC-based diets could not be determined by nonlinear analysis because the first increment of urea provided the best feed/gain. This suggests that the DIP requirement for the DRC-based diet was met at 6.3% of dietary DM. Degradable intake protein requirement for HMC was consistent between Trials 1 and 3 (approximately 10% of dietary DM) and considerably higher than predicted level (7.1% of DM). The greater DIP requirement for HMC is most likely due to greater rate and extent of starch fermentation with HMC compared to DRC. Degradable intake protein requirement for SFC was the same as predicted in Trial 2 (7.1% of DM), but higher in Trial 3 (9.5% of DM). Reasons for differences in estimated DIP requirement for a SFC-based diet are not clear, but may be due to differences in initial weight, intake, and/or method of grain adaptation.

Our results suggest that the average dietary DIP requirements for DRC, HMC, and SFC-based diets are 6.3, 10.0, and 8.3% of DM, respectively. These dietary DIP requirements are highly related to ruminal starch digestibilities reported in literature (78, 89, and 83% for DRC, HMC, and SFC, respectively). Level 1 of the NRC (1996) accurately predicts the DIP requirement for a DRC-based diet. However, DIP requirements for HMC and SFC-based diets are underestimated because Level 1 of the NRC does not account for differences in ruminal starch digestion. Level 2 of the NRC (1996) accounts for differences in ruminal starch digestion, and therefore, may more accurately predict DIP requirements for HMC and SFC-based diets.

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